Potential Discriminating Metrics of Cognitive Task Performance in Mission Command

Working Group 4 - Analysis of Human Decision-Making in a Networked Environment

23-26 January 2012

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Purpose and Agenda

Purpose: To brief the methods of a structured observational study within the Future Combat Systems (FCS) Spin Out Early (SO-E) Force Development Test and Evaluation (FDTE) in 2009 and cognitive metrics implications for mission command (MC).

Agenda

- Background.
- Methods.
- Implications for MC Analysis.

The Cognition Problem for Mission Command

The Army plans to push huge amounts of information across the network without examining the cognitive limitations of Soldiers to make effective use of that information. The Army is:

- Building complex technology solutions.
- Pushing MC responsibilities down to lower echelons.
- Assuming more information is better.

How can the Army measure cognitive limitations and feed results back into DOTMLPF solutions? What DOTMLPF changes do we need to do with respect to workload and MCF?

DOTMLPF – doctrine, organization, training, materiel, leadership and education, personnel, and facilities

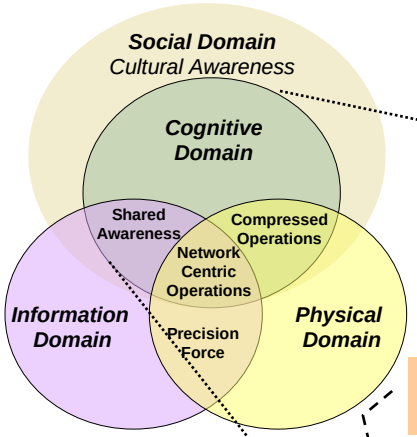
Objective of Cognitive Research

To optimize cognitive task performance such that Soldiers, Leaders, and Teams may achieve mission success operating in the enhanced automated MC environment of the future force.

Goals for Cognitive Measurement:

- Creativity.
  - Promotes active and spontaneous behavior in response to task demands.
- Real-time.
  - Enables synchronization with mission events and the flow of information.
- Objective.
  - Helps shield the metric from bias.
- Unobtrusive.
  - Preserves the integrity of the event and the Soldiers' behavior.
- Diagnostic.
  - Informs designers about the source of performance issues.

Analysis in Relation to DOTMLPF



Source: DOD CCRP Publication "Understanding Command and Control" (2006).

Personnel

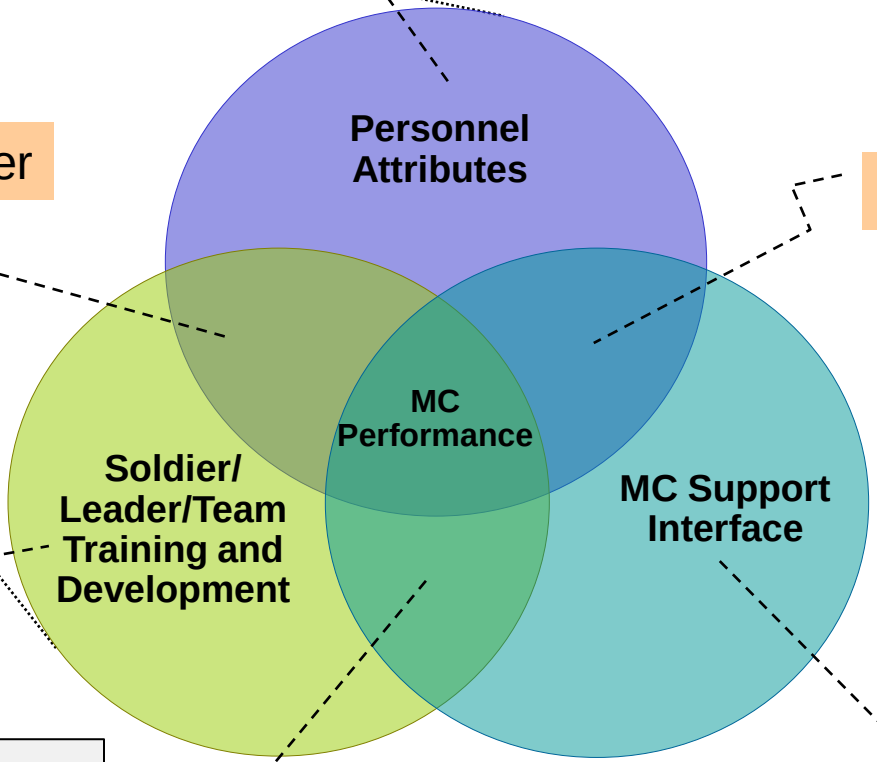
Leader

Organization

Training

Materiel

Doctrine, Facility



Source: TRAC-WSMR Forward

The analytical campaign was structured to provide relevant cognitive analysis to inform DOTMLPF solutions.

CCRP – Command and Control Research Program
DOD – Department of Defense
TRAC-WSMR Forward – TRADOC Analysis Center-White Sands Missile Range (Forward)

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Methods

- Observers were positioned at the battalion (BN) tactical operations center (TOC) and company (CO) command post on Phase 2 Day 1.
- Information about workload and macrocognitive functions (MCF) was collected using pen-and-paper instrumentation.
- Observers were left free to choose whether to record by major event or by regular time intervals.
- Subject matter experts (SME) observed:
  - One CO leader at the command post.
  - Collective behaviors at the BN TOC.
- Intentional variation allowed the instrumentation and protocol to be piloted in a number of ways.

Assumptions About Workload Measurement

- Every task that a Soldier performs will demand attention and contribute to their cognitive workload.
- If workload is either too high or too low, performance suffers.
- Performance can be predicted from a diagnostic measure of workload.
- Workload can be measured through repeatable, behaviorally anchored methods, promoting objectivity.

Workload Scale*

Code	Label	Description
1	Little to No Activity	Level of activity is such that the Soldier/operator is not being engaged at a high enough level to maintain attention, and the Soldier/operator may drift off task, or do other tasks. Behavioral indicators: Station not manned, operator asleep, delays in response to messages, workstation may be manned by others while Soldier/operator is on long breaks.
2	Low Activity	The level of activity does not fully engage the Soldier/operator. Behavioral indicators. Tasks are completed on time.
3	Optimal* Activity	All tasks are being achieved. The Soldier/operator is able to schedule tasks so that all task are achieved in a timely fashion, however lower priority and nonmission critical task might have some delay.
4	High Activity	All mission critical tasks are being accomplished, however some nonmission critical tasks are being dropped, or delayed to a later time.
5	Overloaded	Some mission critical tasks are being dropped, or delayed so as not to be timely.

System development should target the middle of the workload scale.

*Embrey, D., Blackett, C., Marsden, P., & Peachey, M. (2006). *Development of a Human Cognitive Workload Assessment Tool*.

Assumptions about Macrocognitive Functions

- MCF are manifested in observable behavior of Soldier interactions with their environment.
- Using specific operational definitions, they can be recorded in real-time by an SME.
- The co-occurrence of MCF and workload extremes can identify risks to MC performance.

Macrocognitive Functions*

Code	Function	Description
DM	Naturalistic Decision-Making	The identification of a feasible course of action (COA) from experience accumulated in similar situations; it may involve, but does not require, a comparison of the strengths and weaknesses of alternative COAs.
S	Sensemaking & Situation Assessment	Deliberate, conscious process of fitting data into a frame. The frame may be a story, script, map, or other form of representation; the intention is to reduce complexity and simplify the world in relation to a particular goal.
P	Planning	Process of contemplating and devising actions for some future execution following a decision.
AR	Adaptation/ Replanning	Once execution of a plan begins, its progress is monitored in relation to unfolding reality. When reality diverges from the plan, the plan may be modified by cycling back into the planning process, or "replanning." Replanning is the process of modifying, adjusting, and possibly replacing a plan.
PD	Problem Detection	The process by which people first become concerned that events may be taking an unacceptable direction; problem detection involves consideration of actions that may counter the perceived trajectory of events.
C	Coordination	Coordination is the attempt by multiple entities to act in concert. Its purpose is to achieve a common goal by carrying out a shared script or plan.

**Developing the Soldiers and Leaders of Objective Force and Beyond*, Army Research Institute (ARI) Behavioral and Social Sciences, January 2005.

Observation Form

Macrocognitive Function

DM Naturalistic Decision-Making
S Sensemaking/Situation Assessment
P Planning
AR Adaptation/Replanning
PD Problem Detection
C Coordination

Time	Sender	Receiver	Macrocognitive Function*						Work-load (1 - 5)	Comments
			DM	S	P	AR	PD	C		

The observation form leverages cognitive theories about workload and mental activities to enable the study of MC events.

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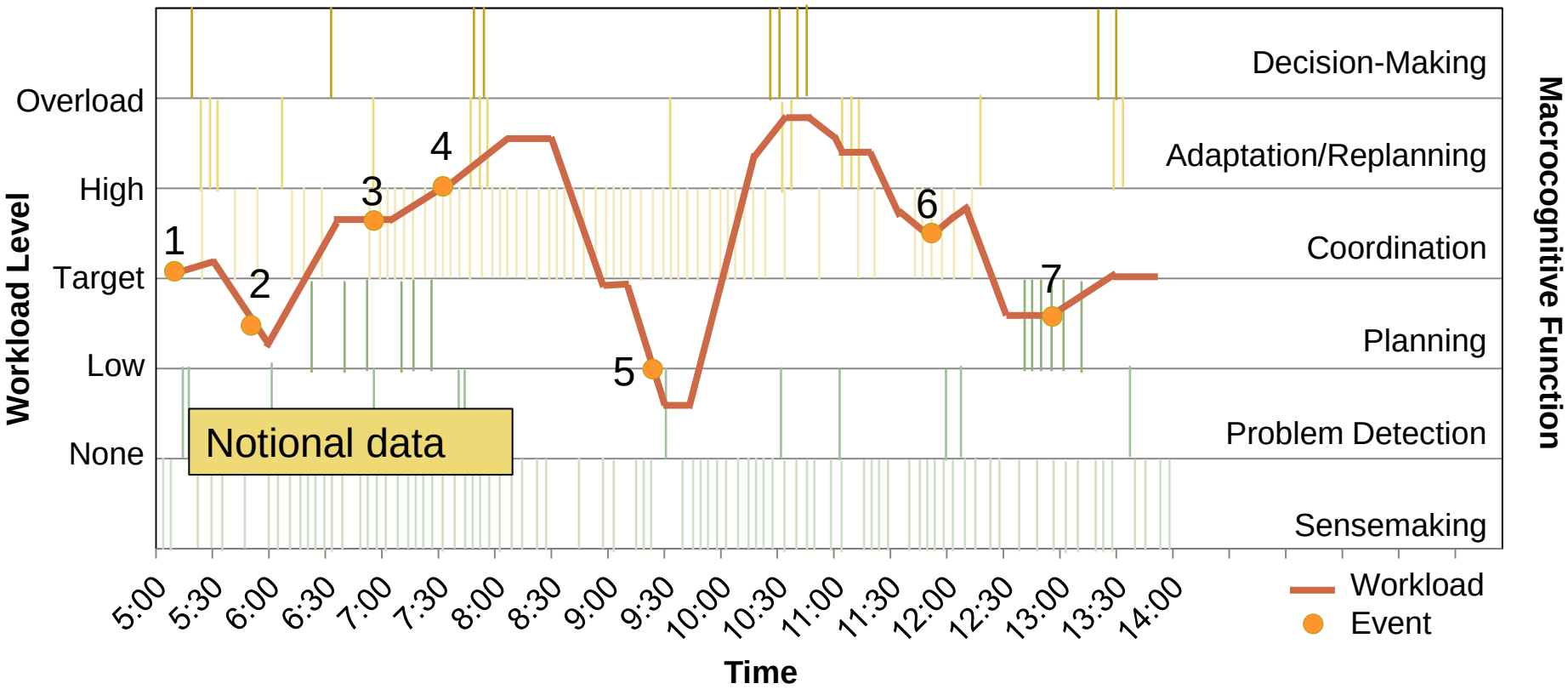
Mock-Up of Workload and MCF Analysis



- Workload and MCF metrics were synchronized with time and events.
- Workload patterns were associated with decision-making and other MCF.
- Overlays of two echelons' data were examined for unit synchronization.
- Synchronizing time data across observers was problematic.

Implications for MC Analysis

- Creativity.
  - The measurement approach fosters spontaneous behavior in response to test events.
- Real-time.
  - Measures have stronger validity when gathered simultaneously with events.
- Objective.
  - Reduces risk of bias using an anchored scale of visual protocols.
  - Both individual and collective monitoring are possible.
- Unobtrusive.
  - Observation occurs without Soldier interruptions.
  - Stationary leaders are easier to monitor than those on-the-move.
- Diagnostic.
  - Approach is more explanatory when workload is linked to leader/team cognitive functioning within MC systems.
  - Metrics are sensitive to changing context and task demands.

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